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JOURNAL

OF THE

MASSACHUSETTS ASSOCIATION

OF

BOARDS OF HEALTH

An Official Quarterly Record of
Information for the Public

OCTOBER, 1900

Proceedings of the July Quarterly Meeting

Subjects: Service Pipes for Water Supplies—
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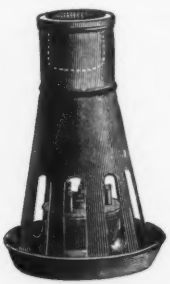

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Carbonate of Magnesia,	.23
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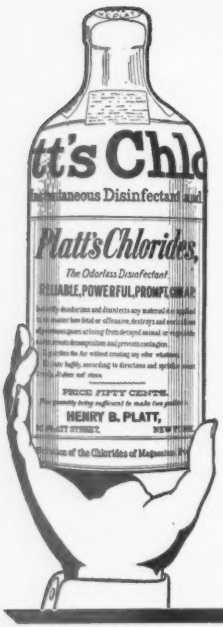
July Meeting, 1900

SUBJECTS: Service Pipes for Water Supplies that corrode Lead and other Metals — The Cess-pool



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The Association holds four regular meetings each year, the annual or January meeting always being held in Boston.

THE OFFICIAL JOURNAL OF THE ASSOCIATION is a quarterly publication, containing the papers read at the meetings, together with verbatim reports of the discussions following them.

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VOL. X. October, 1900. No. 3.

JULY MEETING

OF THE

Massachusetts Association of Boards of Health.

The July quarterly meeting of the Association was held at Gallup's Island, Boston Harbor, on the afternoon of July 19, 1900, the President, Dr. H. P. Walcott, in the chair. The papers presented to the meeting and the discussion thereon follow: —

SERVICE PIPES FOR WATER SUPPLIES WHICH CORRODE LEAD AND OTHER METALS.

BY R. S. WESTON.

The so-called "lead-pipe question," though not a new subject for discussion, has reappeared with a renewed interest in this State, partly because of the increased care with which matters relating to the public health are being studied and partly on account of the recent publication by the State Board of Health of a report upon certain wide-spread cases of plumbism of a serious nature.

Lead-poisoning is, of course, a familiar subject to all of you; and it is not my intention to discuss either the toxicity of water containing small amounts of lead or the maximum amount of lead which

can be safely allowed in a water supply, with due regard to the public health, but rather to call your attention to the various kinds of service pipes in common use, and discuss with you their comparative values from a sanitary and chemical standpoint. The discussion from the hygienic standpoint was ably led by Dr. Abbott at the last meeting.

The chief kinds of service pipes and their present comparative cost for the 1-inch size are tabulated in the table below: —

	Price per linear foot.
Plain black wrought iron	$0.08
Tarred " "	.09
Cement-lined " "	.11
Galvanized " "	.11
Lead-lined " "	.225
Tin-lined " "	.48
Plain lead (Boston weight)	.36
Tin-lined lead	.72
Brass	.36
Wood (1½ in.)	.11

Of these kinds of pipe, the plain, tarred, galvanized, and cement-lined iron and the plain lead pipe are most commonly used. Lead-lined iron pipe has been supplanting lead pipe of late, but the cost of tin-lined pipe is generally prohibitive. The same may be said of the brass or composition pipe, except for inside house connections.

From a sanitary standpoint, all pipes may be classed according to the character of the surface in contact with the water. All of these surfaces are of metal or wood, or metal protected by some coating or lining. The exposed metal surfaces are iron, zinc, lead, tin, copper, and brass.

At this point it may be stated, as a general rule, that the waters which dissolve one metal will dissolve any other commonly used metal. Chemically pure water, simply H_2O, does not appreciably attack any of the metals commonly used for services. However, the presence of oxygen or carbon dioxide in an otherwise pure water makes it more or less of a corrosive agent. Hence most natural waters have some action on metals.

These gases in solution, singly or combined, are the two principal factors in ordinary waters which effect the solution of exposed metal surfaces in service pipes.

I will take up in detail each of the varieties of pipe in the table, and have here samples of each for your inspection.

Wrought-iron Pipe.— Wrought-iron pipe is the cheapest of all services and the one most generally used. Its advantages are, among others, its low cost, its convenience, and its non-poisonous nature, when dissolved in drinking water. Its disadvantages, however, are many. It rapidly rusts and corrodes, and often fills up solidly with rust and scale after a short period of service. Therefore, it is neither durable nor economical. The water from such services stains closets, bowls, and sinks, converts the universal beverage — tea — into ink, and often plays havoc with the family washing.

Galvanized Zinc-plated Pipe.— Zinc is a slight protection only on account of its solubility in waters which attack iron and other metals. The zinc dissolves from the iron pipe in such waters, leaving, of course, the iron surface exposed to the water with all the disadvantages of the latter metal. Zinc, however, is not a cumulative poison in amounts liable to exist in water drawn from galvanized iron services. Galvanizing protects the outside of the service against the action of the soil to a great extent.

Lead.— Lead has been used for conveying water since ancient times. Ancient cisterns were lined with lead, and the Roman aqueducts were made water-tight with the same metal. Cases of lead-poisoning were noted during the Middle Ages.

There are many reasons for using lead pipe for services. It is pliable and easily worked. Therefore, the settling of water mains, sewers, and soil, does not cause it to break, neither is it necessary to be so careful about the trenching and laying as when stiff iron pipe is used. It is very durable in most cases, and does not fill up with rust, neither does it scale off in distinguishable flakes.

On the other hand, lead pipe is expensive to buy and to work, and, as is well known, is soluble in certain waters, especially in the soft-ground waters of New England. This solubility is, of course, the primary cause of lead-poisoning. This solution is practically prevented in certain waters, notably in the hard, clayey waters of the West by substances already in solution, such as silica, which retard the action of the water, and by substances in solution and suspension, such as carbonates and clay, which ultimately cause the forma-

tion of protective coatings on the inside of the pipe, practically preventing further corrosion or solution. The chief constituent of these protective coatings is a basic carbonate of lead, the exact formula of which, however, is not known. This basic carbonate acts as a matrix in some cases, binding some of the suspended matter into a coating. Lead pipe is quite satisfactory where the character of the water is such that solution is practically nil. Lead-lined iron pipe has most of the advantages and disadvantages of plain lead pipe. It costs less, however.

Tin-lined Lead and Tin-lined Iron Pipe.— Tin is the least soluble and, next to iron, the least toxic and the most satisfactory of all the metals usually exposed to water in service pipes; but its high cost is against its general use. No protective coatings form on tin, and the metal is quite rapidly dissolved in certain waters. This solution may be aided by galvanic action caused by impurities in the tin itself; but pure tin is quite soluble in water containing free carbon dioxide and dissolved oxygen. Although the tin thus dissolved is not dangerous to the public health, the lead or iron pipe underneath may be laid bare, with the consequent evils resulting previously referred to.

Brass and Copper Pipes.— Brass and copper pipes are used for hot water pipes and for other house connections. Waters which attack lead, iron, and tin, may also attack copper and brass. Cases of copper-poisoning are rare, however; and the use of this metal where convenience and appearance demand it is allowable.

The characteristics of metal pipes are tabulated below.

(Figures denote the relative degrees.)

	Solubility.	*Toxicity.*	*Durability.*	*Cost.*
Plain iron	1	5	6	1
Galvanized iron	2	2	5	2
Lead	3	1	3	4
Lead-lined iron	3	1	4	3
Tin-lined iron	4	4	2	6
Copper (brass)	5	3	1	5

The best pipe to use in any particular case must be determined largely by local conditions. No general rule can be laid down. Often an investigation is necessary. If upon investigation the ex-

pert finds that a water supply dissolves lead service pipes or that cases of lead-poisoning occur or are liable to occur, what remedy is there?

Obviously, lead pipe services are out of the question; brass and tin lined pipe, at present prices, are generally prohibited by their cost; galvanized pipe is too short-lived to be economical; and plain iron cannot be used advantageously on account of corrosion and iron rust. Therefore, the logical thing to do is either to use wooden pipes or to protect iron pipes with some durable and non-disintegrating coating.

Wooden Pipes.— Wooden pipes have been used for centuries, but until lately they have not been made to withstand pressures of over fifteen to twenty-five pounds. The manufacture of wooden pipes has developed with hydraulic mining; and they are now being used extensively in the West for water services, one company alone having orders for over fifty miles for the season's delivery. These wooden pipes withstand pressure up to two hundred pounds. They are durable, and do not impart any odor or taste to the water. They are not made smaller than 1.5-inch internal diameter, which size costs less, however, than galvanized iron 1 inch in diameter.

Wooden pipes cannot be so easily jointed and prepared as metal pipe. They cannot be used, therefore, in confined places, and are undesirable in exposed work on account of their unavoidable clumsiness. Nevertheless, they have their uses.

Wrought-iron pipe is a very convenient pipe to work; and, if this can be protected by suitable economical coatings, it would be the best pipe for all-round use. The outside of wrought-iron pipe can be practically protected by asphaltic or japan coatings, but such coatings cannot be readily applied to the insides of pipes and couplings.

Several lining materials have been used for wrought-iron pipe. Among them, enamel, tar, and cement are in common use. Enamel and tar linings disintegrate and scale off, and some of them impart a taste to the water. They have not been considered effective and economical for these reasons. Pipe lined with natural cements have now been in use for some decades, and, as the methods of lining are becoming better understood, are more in favor than ever.

Cement-lined pipes were not used for a long time because of the difficulty of lining the joints. This difficulty, with the attendant rusting at the joints, is now overcome by inserting composition thimbles, which protect the couplings and other fittings against the corrosive tendencies of the water, if they are skilfully put in. Tin-lined iron couplings are being used at Taunton with success.

The success of cement-lined pipe depends upon the care with which the lining is performed.

Cement-lined pipe is not usually sold by the dealers, but is lined by the user. The best lining is effected by giving the pipe one coat of cement, allowing it to partially set, and then finishing with a thin coating of cement grout. This last coating fills up any pores in the first coating which may have been left, and causes the inside of the pipe to have a smooth surface. Coatings should be made of light-gravity, neat cement. The cement should be sifted before use.

Cement-lined pipes can be bent but slightly, and are necessarily larger externally for a given discharge than iron or lead pipe; but, when well lined, they make very satisfactory water services, and retain their carrying capacity indefinitely, being free from tuberculation or other incrustation. Brookline has been using cement-lined pipes for over twenty-seven years with uniform success; and Taunton, Waltham, and many other municipalities have done likewise. The outside of the cement-lined pipes should be covered with an asphalt or tar coating, to protect them against the action of the soil.

In conclusion, we may therefore say: —

All waters attack metals more or less, the amount of action depending upon their chemical composition.

Corrosive waters should not be conveyed in unprotected metal (except tin) pipes, especially not in lead pipes.

The only practical substitute for metal is wood, and even this is inferior to cement-lined pipe because of its clumsiness and large size.

Cement-lined pipe, if well made, will last a very long time; and, now that means of protecting the joints have been perfected, it seems to be the best service pipe to use with metal-solvent waters, especially where tin-lined iron is too expensive.

DR. BENNETT F. DAVENPORT.— I am very much interested in this subject, as I have been for several years chairman of the Water Board as well as of the Board of Health of Watertown. We have had experience with all the usual kinds of pipe; but we have used the cement-lined iron pipe in our newer work, and consider it the best there is. I have had unusual personal experience with tin-lined lead pipe. Inspection of some of the pipe made by one of our most reputable companies disclosed the fact that the interior surface of the pipe — the tinned surface — was all crackled, and, after a year's use, innumerable pits had formed between the crackles, apparently erosions through to the lead surface. I examined the water, but could find no trace of lead in it. The occasion of these erosions I could not determine. Probably it was galvanic action. In bending up and unbending the pipe, the harder tin lining had been cracked through probably. I could not determine why there was no lead in the water.

DR. J. E. SANBORN, Melrose.— We are all familiar with the action of carbon dioxide upon lead pipes; that it forms a carbonate of lead which, coating the inner surface of the pipe with its insoluble covering, has been and may be regarded as a natural protection. But I rise to ask if this may be considered a permanent protection.

Does not this carbonate scale off, exposing a fresh surface of lead to poison the water? and may not this scaling process, with its attendant slow poisoning, continue indefinitely? If so, can we ever feel quite safe in trusting lead pipe, no matter how many years in use nor how thoroughly carbonated inside? I beg to ask for information.

R. S. WESTON, Boston.— There is some danger from some waters, especially those containing but little organic matter to act as a binder of the carbonate. I had a case last fall of this kind. The water was one which had a minimum action on lead, and the sample was taken from a long line of pipe which had not been used for some time. On flushing it, a large amount of carbonate of lead was carried out, so much that the water was plainly turbid therewith. This dislodgement of the protective coating is the great objection to the use of lead pipe. Suspended lead, when taken into the stomach, acts, of course, the same as lead in solution.

B. F. DAVENPORT.— Galvanized iron is iron coated with zinc,

which commercially nearly always contains some lead. In my experience, I have known of an instance where some 200 to 300 feet of galvanized pipe discharged water into a wooden reservoir, the bottom of which became covered with a white sediment. This I found on investigation to be composed almost wholly of lead. I am accustomed to tell people, who ask my advice about buying galvanized iron pipe, that water will surely in time dissolve off the zinc, leaving a pipe inferior to what they would have had, had they bought plain iron pipe in the first place. They have thus the privilege, if they desire, of paying an increased price for an inferior iron pipe.

PROFESSOR L. P. KINNICUTT, Worcester.— Is the so-called rustless iron pipe used any? There is or was considerable use of it in Germany. It is prepared by heating the pipes to redness, and passing steam through them, which creates a magnetic oxide. What action does water have on such pipes?

MR. WESTON.— I have known of rustless iron pipes being discussed by those interested in such matters, and of efforts being made to get at information on the subject. But they are not used in this country, at least to any great extent. I have been unable to find any instance of their use. This coating, it seems to me, must be attacked sooner or later, and must be reduced or oxidized. Their use has been generally given up abroad.

DR. GAGE, Lowell.— Is the amount of carbonic dioxide in water a measure of its liability to attack lead pipe?

MR. WESTON.— Other things being equal, yes. The oxygen present will attack the lead, regardless of the carbon dioxide.

F. E. FORBES, Brookline.— For twenty-five years I have given much study to the problem of service pipe,— to find something which will stand the corrosive action of water and yet be a perfectly safe pipe to use, from a sanitary point of view, under all conditions. I have come to the conclusion that cement-lined wrought-iron pipe, with couplings protected with composition ferules, is the best and safest kind of service pipe.

Some waters do not attack lead pipes as badly as others; but we do not know when changes, or what changes, may come to any water supply. Hence we want a pipe which will be safe under all conditions which may arise.

Experience has convinced me that iron pipe can be lined with cement in such a way that the pipe will not rust up, and the water drawn in the houses through it will be of the same quality as that in the mains outside. Such pipe is absolutely safe, cheap, and will last from thirty to fifty years under ordinary conditions.

MR. HILL.— How can private individuals wanting only a few feet of service pipe get cement-lined iron pipe? It is not on the market.

MR. R. S. WESTON.— I would correspond with Mr. Forbes and other water-works superintendents who have had experience with this kind of pipe. They may be able to furnish you with, or tell you where you can get, some. It is not on the general market. If you cannot get cement-lined pipe, I think tin-lined is the next best thing, though wood pipe can be used in some cases. Wood pipe is very useful to convey spring waters for long distances, and has been used on a number of country estates for this purpose.

F. A. WILLARD, Lancaster.— We get cement-lined iron pipe by buying it of the town. Clinton furnishes us with water, and puts in the pipe. We can buy it of that town at cost.

MR. FORBES.— We furnish cement-lined iron pipe in small quantities to any one in Brookline and vicinity for their own grounds.

THE CESSPOOL.

BY LEMUEL P. KINNICUTT, OF WORCESTER POLYTECHNIC INSTITUTE.

Mr. President and Gentlemen,— About ten years ago I had the pleasure of listening to an address given before this society, in which nearly all the ills which humanity is liable to were traced back to the cesspool. The address represented the general opinion held at that time; yet to-day the latest work on sewage disposal shows us that our forefathers, in using the cesspool, were using, unawares, a most efficient method for the disposal of solid putrefying substances. These rapid changes of opinion in sanitary science regarding every-day matters are most confusing; for what we hold as true to-day, we are told to-morrow is all false. We all of us remember the numbers of meetings when plumbers' laws and regulations have been discussed,

and the dire effects that must follow the breathing of sewer gas; yet men like Abbott, of Pennsylvania, and our own Vice-President now tell us that no distinct disease can be traced to sewer gas.

The Massachusetts State Board of Health in 1887 investigated the subject of ice; and the belief was that in large cities like New York, or in any place where ice was taken from an unknown source, ice-water should be prohibited, as there was great danger of contracting typhoid fever in this way.

So with the cesspool. As I have said, ten years ago we regarded it as a most unholy and obnoxious survival of the unsanitary life of our forefathers. Now we are taught, not only that it was not, after all, a very bad method for the disposal of household refuse, but are shown the advisability of using it on a large scale for the partial purification of the sewage of cities.

What has caused this change of opinion regarding the cesspool? It is due chiefly to the careful consideration of a fact well known to us all; *i.e.*, that, although a large amount of solid animal and vegetable matter was being run, day by day, into the old-fashioned cesspool, the cesspool did not fill up, and at the end of the year the amount of solid matter at the bottom was very small in comparison to the amount that had been added during the year. Do not most of us remember the cesspool of our boyhood days that was not cleaned out oftener than once in three or four years? Yet how few of us ever asked the reason why it was not necessary to do so every three or four months.

Why this was not necessary and how the cesspool has been adapted to the disposing of sewage on a large scale, I take as the subject of my fifteen-minute talk.

To answer the first part of this question, it is necessary to speak briefly regarding bacteria and the work they do in decomposing dead animal and vegetable matter.

Bacteria are a low form of vegetable organism, which multiply by a process of transverse division. Though commonly considered as dangerous enemies, they are, in fact, our greatest friends; for it is only a comparatively few species, those that exist on living matter, that cause disease. The great majority obtain their nutritive material from dead animal and vegetable matter, and resolve these substances

into simpler compounds, as carbon dioxide, water, ammonia, nitrates, which are the food supply of higher vegetable life. Were it not for the presence of these bacteria, disposing, as they do, of effete organic matter and changing it into plant food, human life on this earth would, seemingly, be impossible. These are the bacteria that are present by the hundreds in a cubic foot of air, and in a cubic centimetre of so-called pure water, and by the millions in a cubic centimetre of polluted water, or of sewage.

Bacteriology as a science may be said to date from Pasteur's experiments on the causation of the putrefaction of beer and the souring of wine, in the middle of the present century; and it is only at a very recent date that there was any reliable knowledge as to the action of bacteria in the purification of sewage.

Fresh sewage contains, in immense numbers, the class of bacteria which live on dead organic matter, and which cause its decomposition. These bacteria can be roughly divided into two great groups, each containing numerous species. These groups are called the anaërobic and the aërobic groups. The anaërobic group embraces all those species that live, grow, and multiply out of contact with air and light; the aërobic, those species that live, grow, and multiply best in air and light. Each group plays its own special part in the destruction of effete matter and the organic substances contained in household waste. The anaërobic bacteria act first. They disintegrate the solid animal and vegetable matters, liquefy them, and bring them into solution. The aërobic bacteria act upon these disintegrated and liquefied compounds, and by a process of oxidation change them into harmless gases.

For the destruction of dead organic matter, both groups of bacteria are necessary,— the anaërobic to disintegrate and liquefy the complex organic substances, the aërobic to change those simplified and liquefied compounds into harmless products.

Taking the above as a brief outline of what takes place in the decomposition of excreted and effete matter, we are in a position to consider the changes that take place in the cesspool.

Into the cesspool enter all the waste products of human life, and with these waste products millions of bacteria, both anaërobic and aërobic. But, the contents of the cesspool being practically shut off

from air and light, it is a most suitable environment for the development of the anaërobic bacteria. These bacteria immediately begin to act upon the solid compounds in the excreted and other household waste. The complex nitrogenous substances are broken up and liquefied, also compounds like cellulose in its various forms, as paper, starch, woody fibre, are disintegrated; and, finally, if the action continues a sufficient time, all that remains in a solid state is practically what we can call the ash, or the mineral matter of the animal and vegetable substances that entered the cesspool. The action that takes place in the cesspool might be compared to the process of combustion. If the substances that entered the cesspool had been burnt in a furnace, we should have left behind only the ash, all else being given off in the form of various gases. In the cesspool the bacteria have taken the place of heat. All the solid matter that remains is the ash. All else, however, has not been changed into gas, but, to a great extent, into substances soluble in water.

Liquid that passes from the cesspool as it leaches through the soil, or as carried away by a drain and allowed to run on land, comes in contact with air; and the conditions become favorable for the development of the aërobic bacteria, and the final process of purification begins. The liquefied compounds are most easily acted upon by the bacteria, and the compounds changed, as I have said, into harmless gases and mineral substances.

It thus appears that our forefathers, without any knowledge of bacteriology, devised one of the most efficient methods for the purification of household waste, and one which I will show in a moment has, during the past two years, been utilized for the purification of sewage in large cities, and has great promise of being most successful.

The question as to the dangers attached to a cesspool I do not at this time care to consider at any length; but it seems to me that the danger arising from the use of cesspools has been overestimated. Certainly, in the decomposition of the solid complex compounds by the anaërobic bacteria, a large amount of gas is given off. This gas, however, is composed chiefly, as I will show later, of carbon dioxide, marsh gas, hydrogen, and nitrogen, and resembles concentrated sewer gas, but does not contain, as far as we know, any amount of sulphite of hydrogen or other poisonous gas.

If the liquid in the cesspool is on different levels at different times, so that the sides at times become dry, there may be danger of some pathogenic germs being in the gas that escapes from the cesspool; but the above condition cannot exist if the inlet pipe enters the cesspool at a lower level than the exit drain.

If the liquid in the cesspool percolates through the sides of the cesspool and the soil is hard clay, it may, while still containing a large amount of soluble polluting matter, enter a water supply, as a well or a stream; but, if the cesspool is in sandy soil, there is very slight, if any, danger, as late experiments have shown that organic matter in the condition that it is in on leaving the cesspool is changed with the greatest rapidity into absolutely harmless compounds. If the liquid is carried by a pipe from the cesspool and discharged over land not near a well or stream, it seems that there could be no danger. As to the escape of any dangerous gas from the soil near a cesspool, I do not see how it is possible.

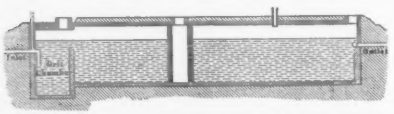
Having thus tried to answer the question why cesspools do not quickly fill up with solid matter, and also to describe what changes take place in the cesspool, I wish, in the few minutes at my disposal, to describe how this method has been made use of by sanitary engineers for treating sewage on a large scale.

Mr. Scott-Moncrieff, the well-known sanitary engineer of Ashland, England, was, I believe, the first to recognize that the bacterial purification of sewage took place in two stages, and that the first stage should serve as a prelude to further treatment. He erected in 1891 at Ashland, a tank, or cesspool, for the express purpose of liquefying the solids in sewage, in which the sewage was forced upward over a bed of stones. (The diagram on p. 86 represents his liquefying tank.)

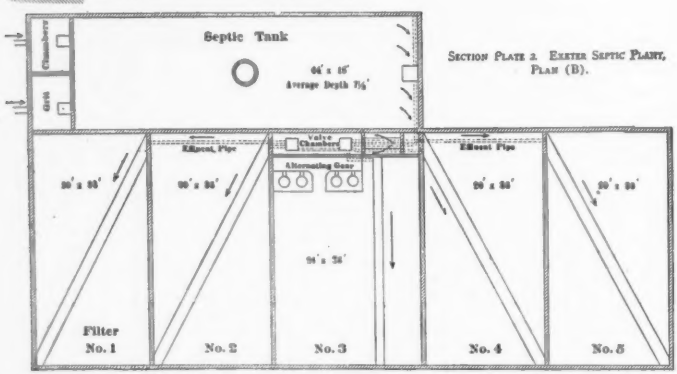
The credit, however, of showing that a modified cesspool could be advantageously used for the treatment of sewage of cities and towns belongs to Mr. Cameron, of Exeter, England. The process was named by him the septic treatment, and it is by this name that it is now known.

He built at Exeter, England, an underground tank of cement concrete, sixty-five feet long, sixteen feet wide, and of an average depth of seven feet, having a cubical capacity of 53,000 gallons. The tank was covered with a concrete arch; and a portion of the tank near the

inlet was made about three feet deeper than the rest, and partially cut off by a low wall, forming a couple of pockets, or grit chambers, to retain sand, grit, and road washings. The inlet was carried down to a depth of five feet below the surface, so that air could not make its way down with the sewage, and also so that gases could not escape from the tank back into the sewer. The effluent outlet was also below the level of the liquid; and, to avoid any current that would be liable to carry with it any of the floating matter from the surface, a cast-iron pipe was carried across the whole width of the tank fifteen



EXETER SEPTIC TANK. SECTION (A).



SECTION PLATE 2. EXETER SEPTIC PLANT, PLAN (B).

inches below the surface, and on the lower side of this pipe there was a continuous opening about one-half inch wide. An iron pipe about one and one-half inches in diameter extended out of the top of the tank to allow the escape of gases which were formed, and the sewage in the tank could be inspected by opening a manhole at one end or descending into a manhole constructed in the centre and having glass windows.

At the plant at Exeter there are also five beds (Plate 2 B), thirty-six feet long, twenty feet wide, and four feet deep, made water-tight and filled with crushed clinker or coke breeze. Such beds are admi-

rably adapted for the cultivation of aërobic bacteria; and the liquid as it comes from the tank, having undergone the first stage in the process of purification, is now in just the right condition to be acted upon by the aërobic bacteria.

In August, 1896, the main sewer of St. Leonard's, a suburb of Exeter with a population of 1,500 and an average daily flow of sewage of 57,000 gallons, was connected with the tank; and the above volume of sewage has been continuously passed through the tank since that time. The effluent from the tank falls over a wall about one foot high, which effects slight aëration, and then by means of the alternating gearing is caused to pass automatically on one or the other of the beds.

Visiting the plant, the effluent from the tank first strikes the attention. It is a brownish-colored fluid, free from palpable suspended matter, but does contain solid matter in a state of very fine subdivision, almost like river silt. It has an odor, but at the four different places where I examined it the odor is not more offensive than that given off from the first or second basin used in the chemical precipitation process.

The liquid in the tank is covered with a thick, floating mass, dark brownish-yellow in color, through which bubbles of gas are continually breaking. This floating mass is said to have formed during the first six or eight weeks the tank was in operation, and not to have increased much in thickness since that time. It appears to be composed of organic matter, but, in fact, I believe it is principally a mass of micro-organisms; and it is not till this floating mass has been formed that active septic action takes place. At the bottom of the tank there was last summer a deposit two or three feet in thickness, the accumulation of three years, as the tank has never been cleaned out. This deposit looks like sewage sludge, though it contains much less organic matter. From the iron pipe at the top of the tank issues a volume of gas, which, when ignited, burns with a colorless flame about one foot in height. The unignited gas has no very marked odor, and does not contain appreciable amounts of sulphide of hydrogen.

What are the changes that take place in this tank? They are exactly those that take place in the cesspool. The most marked

change is the disappearance of solid matter, and it has been demonstrated that from one-half to two-thirds of the total solid matter has decomposed and liquefied.

In this decomposition a large amount of solid matter is changed into gaseous compounds, as ammonia, carbon dioxide, marsh gas, hydrogen, and nitrogen. Of these, ammonia and part of the carbon dioxide remain in solution; while the others, being insoluble in water, escape from the tank.

That a large volume of gas is given off from the septic tank is seen not only at Exeter, but everywhere the septic tank is in use. The gas at Exeter burns with a flame over one foot in height. The only determination as to the amount of gas that is given off is, so far as I can learn, one that was made by H. W. Clark, chemist for the Massachusetts State Board of Health, working with a very small experimental tank. His results indicate that from .5 to .6 of a cubic foot of gas are formed from 100 gallons of sewage.

Analyses of the gas have, however, been frequently made; and, though of course it must vary greatly from time to time, the following analyses made by Dr. S. Rideal give an idea of its composition:

Carbon dioxide	.3 per cent.
Marsh gas	20.3 " "
Hydrogen	18.2 " "
Nitrogen	61.2 " "

Who first saw that a similar action to that which takes place in a closed tank must also take place in a large open tank is not known. Undoubtedly, the same thought occurred to many persons at about the same time; for of course the conditions in both must be practically the same.

No free oxygen can be present in an open tank when full of sewage; and, the sewage containing, as it does, a large amount of suspended matter, very little light can penetrate down from the surface. Whoever may have first used an open tank for septic action, I found them last summer being used experimentally at Accrington, Huddersfield, Leeds, and Manchester. In all these places an old tank, which had formerly been used for chemical precipitation, had been turned into a septic tank, all the change necessary being to place the outlet

so that the effluent opening should be three to four inches below the surface of the liquid, although, of course, in the building of such a tank, it would be better to have the inlet also beneath the surface. In all these places the general appearance of the liquid in the tank was the same, very dark and opaque, the surface coated over with a thick layer of solid matter, and the activity of the action in the tank shown by the thousands of bubbles of gas escaping through this layer of solid matter. The effluent was of a dark brown color, containing suspended matter in a very fine state of subdivision; but neither the odor given off from the tank or from the effluent was so offensive as to prevent its use by towns or cities. That the action which takes place in the open septic tank is very similar to that which takes place in the closed tank is shown by a series of experiments made by Mr. Fowler at Manchester. He made daily analyses for one month of the effluent from an open tank and of the effluent from a closed tank, both being supplied with the same sewage. The following table gives the average of these daily analyses. The results, as seen, are almost identical: —

Parts in 100,000.	*Open tank.*	*Closed tank.*
Free ammonia	3.20	3.10
Albuminoid ammonia	.50	.51
Oxygen consumed	8.46	8.43
Chlorine	16.40	16.10

The real practical value of the septic tank, or we might say the cesspool, is that it destroys suspended matter without forming any great amount of sludge, or precipitate, thus having a great advantage over any chemical precipitation process; that it seems to bring cellulose into at least partial solution, thus preventing the coating over of bacteria beds, either those of intermittent filtration or contact with a layer more or less impervious to water; that it breaks up the more complex organic compounds, forming substances that are more easily acted upon by the nitrifying bacteria than the compounds in raw sewage. There is also another advantage in the use of the septic tank that it seems to me may be of great importance. In all bacterial treatment of sewage the changes that we have followed in the septic tank take place; but in the systems of intermittent

filtration beds and contact beds, the second phase of purification, nitrification, is also being carried on at the same time. If in either of these systems too little air is supplied, the aërobic or nitrifying bacteria cease to work, their place being taken by the anaërobic bacteria, which are unable of themselves to finish the process; and, whenever the anaërobic bacteria have obtained the upper hand, as is the case when a bacteria bed is overworked, the bed becomes foul, and the product obtained is similar to a septic tank effluent. By using a septic tank, allowing the effluent to come in contact with air and then passing it onto a bacteria bed, the two phases of purification are kept separate; and better work is naturally to be expected.

I stated at the beginning of this paper that what we hold as true to-day we are told to-morrow is all false; and so, in a year or two from now, I may come before you, and say that the changes that take place in the cesspool are not due to bacteria, but are due to chemical action. And I say this now because there are certain facts that point in this direction. There is a class of chemical substances known as enzymes, or unorganized chemical ferments, which are the products of vegetable and animal life, and which in minimum amounts, without being themselves used up, are able to break up and decompose large amounts of complicated and insoluble compounds. Thus the enzyme known as diastase decomposes starch; lifase, many fats; cytase decomposes and dissolves cellulose. These enzymes seem to decompose the complex organic substances by what, chemically speaking, is called hydrolysis,— the breaking up of a compound by the addition of water. In this way, substances like albumen may be broken up, with the formation of nitrogen, ammonia, hydrogen, marsh gas, and carbon dioxide; substances like cellulose, into hydrogen, marsh gas, and carbon dioxide. Many of the enzymes being the products of anaërobic bacteria, they would naturally occur in the septic tank; and a large amount of the decomposition may thus be chemical rather than bacterial.

Whatever is the cause of the changes that take place in the cesspool, or septic tank, the changes are those that I have described; and I only hope that I have been able to point out to you that the most modern method of treating sewage is, in fact, the method of our forefathers.

ROBERT SPURR WESTON.— This is a very interesting and important subject. It is particularly interesting to note the enormous strides which the subject of sewage disposal has made in a decade, especially with reference to the amount of sewage which can be disposed of on a given area of bed.

In the eighties we were talking of vast farms as necessary for the disposal of this matter. In the nineties we have been talking of reduced areas or bacterial beds. Since 1896 we have been still further reducing the area, as Professor Kinnicutt has told you, by first putting the sewage through a cesspool, thereby disposing of a large part of the suspended solids of the sewage. Now we are learning how we can still further reduce the areas by using very coarse, porous material, which will more effectually expose the sewage in thin layers to the action of the air and bacteria.

DR. GAGE.— Is there any danger of the pathogenic bacteria which may be in the sewage getting out in the final effluent?

DR. KINNICUTT.— That depends on the rate of filtration, also the degree of purification. No definite experiments have been made on this subject.

DR. GAGE.— The presentation of the ice question is new to me. I had always supposed the danger of ice from polluted sources was much greater than has been represented. Early in the spring I had a case of typhoid fever breaking out soon after the family had taken a new supply of ice cut from a known polluted source. It had been put in a silver ice-pitcher, from which the person drank freely. I corresponded with Dr. Abbott, and he thought there was some danger from such a source, Professor Sedgwick also testified in court that there was some danger from a polluted source.

DR. KINNICUTT.— The vitality of typhoid fever germs is greatly reduced by freezing. I did not mean to say that there is *no* danger from ice from polluted ponds.

DR. ABBOTT.— Personally, I do not claim to know about the danger from ice. I only take the opinions of those who I think do know. For myself, I do not care to take ice from a source that is polluted. I have recently made a change, in order to get my ice supply from a source that was less suspicious. On the question of cesspools I do not claim to be an expert, but I give you a bit of my experience. I

built a new cesspool fifteen years ago, and it has not been cleaned out yet. It is built of stone, not water-tight; and the overflow runs off through a loose pipe into the garden. My neighbors don't even know that it exists. As it is no nuisance, I don't propose having it made one by having it cleaned out. Whenever the system of sewers is introduced in the town where I live, I shall be glad to take advantage of the system, since that is the better method of disposal.

DR. DURGIN.— It is of importance that the cesspool matter be so dealt with as not to make mischief,— that it shall be handled so that neighbors shall not complain of its being a nuisance. The common cesspool overflows, and perhaps runs over on to the neighbor's premises. As usually managed, it stinks badly, and complaint is made.

Now how shall we tell people to build cesspools so that this shall not happen? If the material is filtered through the proper medium, the effluent may flow into a brook or over the surface, and cause no nuisance; but the trouble in many cases is the want of proper location for the cesspool, with the proper amount of sand or gravelly soil for the necessary filtration.

People come to our office, and say their conditions are such that they must drain their cesspools into the brook or garden. If they locate their cesspools so that there are six or seven feet of sand through which this water may filter, it will not come to the surface to make a nuisance. I am not surprised at Dr. Abbott's case, owing to the fact that the sands of Wakefield furnish sufficient filtration; but we do not all live where there is a sufficient amount of sand for such a purpose. This is one of the most interesting subjects we have had before our Association for years.

JAMES KIMBALL, Springfield.— Our experience in Springfield corresponds very largely with Dr. Durgin's, although our soil is of sandy formation. The cesspools fill up quickly, and we are troubled by their overflowing. These places are mostly on new streets where there are no sewers, but where there is city water, which at certain seasons of the year contains a large amount of vegetable matter that evidently assists in the formation of a sediment, preventing the sand from absorbing the drainage. Consequently, it must come to the surface. As soon as this occurs, complaints come from tenants and neighbors.

DR. KINNICUTT.—A cesspool on a hard clay soil is a hard question to deal with. Still, it can be done. It is only a question of dollars and cents. Scott-Montcrieff tank, as this diagram shows, is only a modified cesspool, the liquid contents being allowed to pass successively through nine trays filled with sand. Analysis of the liquid after passing through the last tray shows it to be in such a state that it cannot possibly cause any trouble. For large country places a system of bacterial beds can easily be constructed. In England I have seen such places, where the effluent from the bacterial beds entered an artificially constructed pond, which was filled with fish and surrounded with flowers and shrubs, forming a picturesque bit of scenery.

JAMES C. COFFEY, Worcester.— Do you recommend individual cesspools in ordinary city lots?

PROFESSOR KINNICUTT.— Certainly not. In a city with a sewerage system, householders on streets provided with sewers should be obliged to enter them. Cesspools are only for houses which cannot discharge the household waste into a sewer.

MR. COFFEY.—As a practical health officer, I have some knowledge of cesspools. We all know that they are constant sources of trouble. In my city (Worcester), houses are being built very rapidly in new localities, often in advance of sewers. Sometimes a cesspool will run over in a month; and the neighbors will come into the office in a state of great excitement, demanding the abatement of the nuisance at once. I was in hopes, while listening to the first part of the professor's paper, that I could say to such people: Don't get excited. Have patience. In a few days the aërobic bacteria will get in their work, and there will be no more trouble. But, before the paper was finished, I saw that the system is to be used by communities rather than by individuals. Even in sandy and gravelly soils the cesspools do fill and run over very frequently, although they last much longer, to be sure, than in clay soils. It is my experience that trouble is likely to occur in any soil after a few years. After cleaning out these cesspools, I have advised driving an iron bar down through the clogged soil, in order to get contact with clean soil. After all, in my opinion, these are makeshifts, to be used only until a sewer can be obtained.

DR. B. F. DAVENPORT.— When you have a sewerage system, what do you do with the cesspools?

MR. COFFEY.— Clean them out, and fill them up.

DR. WALCOTT.— I would say, in behalf of the State Board of Health, that on a legislative order we investigated the ice supply of Massachusetts, examining many samples from contaminated sources. Reports of this investigation and our recommendations appear in one of our annual reports. The result of the investigation was that we recommended that ice from infected ponds should never be used. Investigation in the laboratory has confirmed this, and I see no reason to change my opinion. Let ice from infected ponds alone.

WALTER C. KITE, M.D., Milton.— While this little matter of a complaint book is of no interest to city boards of health, it may prove helpful in towns where there are not a large number of complaints, and where the complaints are sent to the secretary of the board of health and are investigated by the agent, as it obviates the necessity of the secretary writing letters to the agent in regard to complaints, compels the agent to put the results of his investigations in writing, encourages promptness on the part of both secretary and agent, and furnishes a convenient method of filing.

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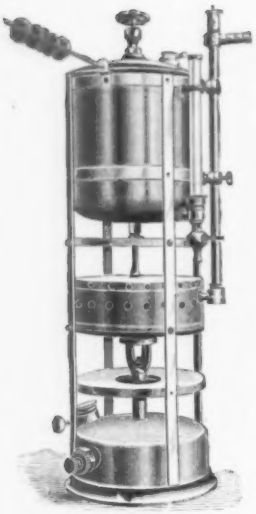

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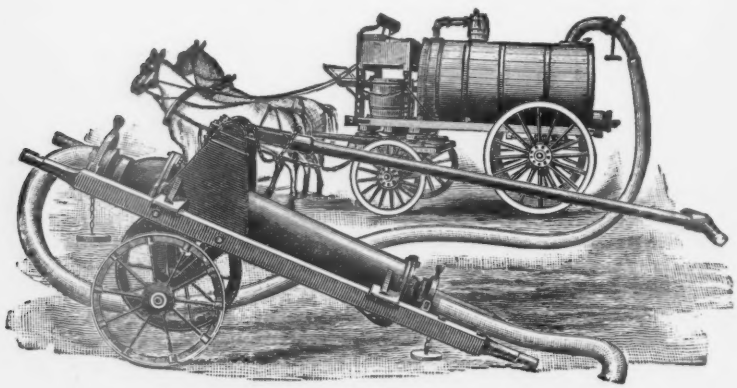

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